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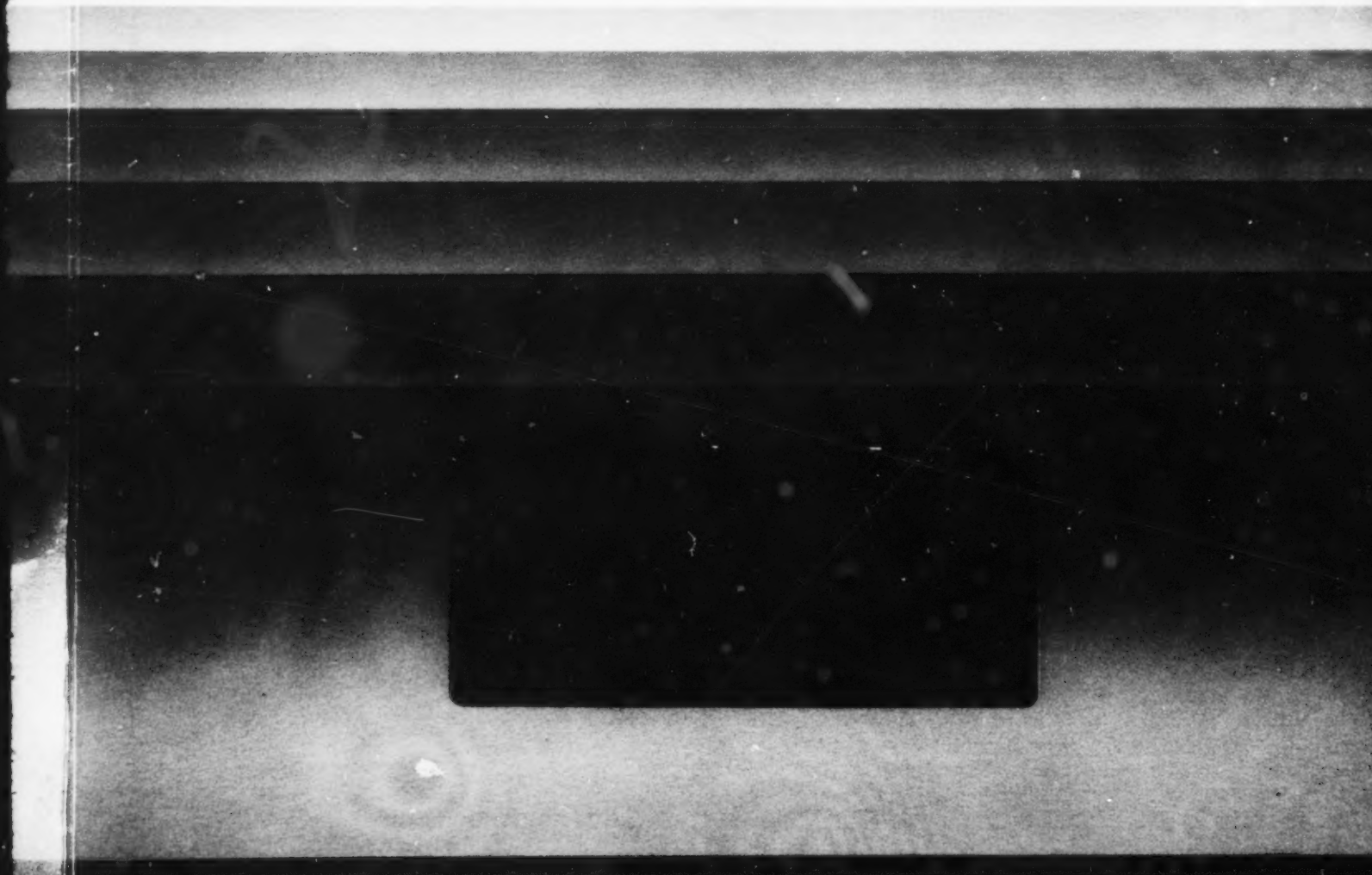

Inland Waters Directorate
Saskatoon, Saskatchewan, Canada
Direction générale des eaux intérieures
Saskatoon, Saskatchewan, Canada

Canada

92-07068/

ISSN 0838-1992

C.S L. Ommanney

Hydrological Sciences Division
National Hydrology Research Institute
Environment Canada
Saskatoon, Saskatchewan
S7N 3H5

SNOW IN CANADA
REFERENCES (1988-1990)
AND RECENT WORK

NHRI Contribution No.90050

August, 1990

MANAGEMENT PERSPECTIVE

The establishment of a national or international focus for hydrology at the National Hydrology Research Institute means that staff there accept positions with national and international bodies. One appropriate activity is that of Canadian national correspondent for one of the commissions of the International Association of Hydrological Sciences. Simon Ommanney is the National Correspondent for the International Commission on Snow and Ice. One of his roles is to prepare an annual report on snow and ice research in Canada for publication in the Canadian Geophysical Bulletin. This report contains a bibliography and other background information for the 1989 report (CS-90054).

PERSPECTIVE DE GESTION

L'établissement à l'Institut national de recherche en hydrologie d'un groupe national ou international de recherche spécialisée en hydrologie signifie que les employés de l'Institut sont prêts à accepter des postes dans des organismes nationaux ou internationaux. Une activité appropriée est celle du correspondant canadien pour l'une des commissions de l'Association internationale des sciences hydrologiques. Simon Ommanney est le correspondant national pour la Commission internationale de la neige et de la glace. L'un de ses rôles consiste à préparer un rapport annuel sur la recherche en matière de neige et de glace au Canada pour publication dans le Bulletin canadien de géophysique. Le présent rapport contien une bibliographie et des renseignements supplémentaires pour celui de 1989 (CS-90054).

FOREWORD

As Canadian Correspondent to the International Commission on Snow and Ice (ICSI), C.S.L. Ommanney is responsible for preparing annual reports on snow investigations in Canada for the Associate Committee on Hydrology and their review of current activities for the Canadian Geophysical Bulletin. This report complements that review. It summarises references to work done in Canada, on snow, and by Canadian glaciologists; published between 1988 and 1990. The listing includes unpublished reports and newspaper articles. The latter, because of the location of the author and the availability of information, are biased towards Saskatchewan. The scientific articles reflect the activity of university, government and private sector scientists in different parts of the country.

As this is only a preliminary listing, readers are asked to advise the compiler of any errors or omissions. Many of the references have not been verified and some of these may not in fact deal with snow in Canada or may not be authored by Canadians.

The Appendix contains copies of the data sheets submitted to the ICSI Correspondent from glaciologists across Canada in res-ponse to a request from the Associate Committee of Hydrology for input to the Canadian Geophysical Bulletin. These sheets have information on completed, current and future work together with contact names and numbers.

As background information for the ICSI report, other companion reports have been prepared on Glaciers (CS-90051), Floating Ice (CS-90052) and Permafrost (CS-90053). These are available on request from the National Hydrology Research Institute.

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APPENDIX

CURRENT SNOW RESEARCH

Organization and Address Department of Geography, Trent University, P.O. Box 4800, Peterborough, Ontario, K9J 7B8	**Tel.No.** 705-748-1475
Department/Branch Geography	**FAX No.** 705-748-1246

Researchers

J.M. Buttle

Project Title **Snowmelt Runoff in Suburban Catchments**	**Status** **New** [ ] **Ongoing** [X] **Completed** [ ]

Objectives

1) Monitor and model urban runoff under snowmelt conditions;
2) Assess influence of progressive basin development on snowmelt runoff response;
3) Model chloride loadings to receiving water bodies during snowmelt in suburban environments.

Methods

Lab [ ] **Field** [X] **Modelling** [X] **Others**

Findings

Suburban areas experience higher snowmelt rates than open fields and forests, largely as a result of increased net radiative fluxes in the vicinity of houses. Suburban catchments respond more rapidly to snowmelt and rain-on-snow inputs than rural basins do. Progressive suburban development over a 14-year period led to a 6-fold increase in spring quickflow response ratio and anincrease in the number of snowmelt events that generate quickflow.

Publications

Buttle, J.M. and F. Xu, 1988. Snowmelt runoff in suburban environments. Nordic Hydrology, 19(1), 19-40

Buttle, J.M., 1990. Effects of suburbanization upon snowmelt runoff. Hydrological Sciences Journal, 35, in press

Organization and Address	Tel.No.
NWRI, Canada Centre for Inland Waters, Environment Canada, Burlington, Ontario, L7R 4A6	416-336-4611
Department/Branch Lakes Research Branch	**FAX No.** 416-336-4989

Researchers

D. Gregor

Project Title	Status	
Deposition and Fate of Atmospheric Contaminants in Arctic Aquatic Systems	**New**	[ ]
	Ongoing	[X]
	Completed	[ ]

Objectives

To quantify annual fluxes of contaminants to arctic aquatic systems. To determine the fate of these contaminants in selected aquatic systems.

Methods

Lab [X] **Field** [X] **Modelling** [ ] **Others**

Findings

1. Organochlorine deposition in the Arctic to the snowpack is about equal to that for temperate regions of Canada.
2. PCB deposition, based on studies of Agassiz Ice Cap, have decreased by about 50% between 1969/70 and 1986/87.
3. Trends for oc pesticides are ambiguous due to revolatization to the atmosphere.

Publications

Gregor, D.J. and W.D. Gummer, 1989. Evidence of atmospheric transport and deposition of organochlorine pesticides and polychlorinated biphenyls in Canadian arctic snow. Environmental Science and Technology, 23(5), 561-565

Organization and Address Department of Geography, University of Windsor, Windsor, Ontario, N9B 3P4	Tel.No. 519-253-4232: Ext.2171
Department/Branch Geography	FAX No.

Researchers

J.R. Heron

Project Title Hydrology of snow-filled Arctic stream valleys during break-up - 1989	Status New [ ] Ongoing [X] Completed [ ]

Objectives

Methods
Lab [ ] Field [ ] Modelling [ ] Others

Findings

Publications

Organization and Address	Tel.No.
Cold Regions Research Centre, Wilfrid Laurier University, Waterloo, Ontario, N2L 3C5	519-884-1970
Department/Branch Geography	**FAX No.** 519-886-9351

Researchers

K. Hewitt, G.J. Young and J. Gardner

Project Title	Status	
Snow and Ice Hydrology Project	**New**	[ ]
	Ongoing	[ ]
	Completed	[X]

Objectives

Elucidation of hydrology of the Upper Indus Basin, Pakistan.

Methods

Lab [ ] **Field** [X] **Modelling** [X] **Others**

Findings

Given in annual reports 1985-89. Final report nearing completion.

Publications

Numerous

Organization and Address	Tel.No.
INRS-Eau, 2700 rue Einstein, C.P. 7500, Sainte-Foy (Quebec), G1V 4C7	418-654-2533
Department/Branch INRS-Eau	**FAX No.** 418-654-2562

Researchers

H. Gerald Jones, M. Duchesneau and S. Gamache

Project Title	Status
Chemical Dynamics of Nitrogen Species in Seasonal and Perennial Snow Covers	**New** [ ] **Ongoing** [X] **Completed** [ ]

Objectives

To determine the abiotic and biotic processes which influence the translocation and transformation of N-species (NO_x, HNO_3, NO_3, NH_4^+, N-org.) in snow.

Methods

Lab [X] **Field** [X] **Modelling** [X] **Others**

Findings

HNO_3 vapour pressure in snowpacks will cause translocation of this species within snow and at the snow-atmosphere interface. N mass balances in the snow depend on dry deposition, wind and rain-on-snow events; in particular NO_3 and NH_4 contents in wet melting snow are subject to depletion due to the activity of microbial and algal populations.

Publications

Jones, H.G., Tranter, M. and T.D. Davies, 1989. The leaching of strong-acid anions from snow during rain-on-snow events: evidence for two component mixing. IAHS Publication No.179, 3-13

Jones, H.G. and C. Deblois, 1987. Chemical dynamics of N-containing ionic species in a boreal forest snowcover during the spring melt period. Hydrological Processes 1(*), 271-282

Organization and Address	Tel.No.
INRS-Eau, 2700 rue Einstein, C.P. 7500, Sainte-Foy (Quebec), G1V 4C7	418-654-2533
Department/Branch INRS-Eau	**FAX No.** 418-654-2533

Researchers

H. Gerald Jones, J. Roberge and B. Taylor

Project Title	Status	
Nutrient dynamics of meltwater movement through boreal forest basins.	New	[ ]
	Ongoing	[X]
	Completed	[ ]

Objectives

To determine the factors which influence the flux of nutrients from snowpack to surface water systems in the boreal/taiga biomes.

Methods

Lab [X] **Field** [X] **Modelling** [ ] **Others**

Findings

Little decomposition occurs under snow in the boreal forest; decomposition rates have been quantified through the mid-winter and spring-melt periods. Sub-ice nutrient fluxes of meltwater and throughflow inputs to a small boreal lake have been tracked; nutrient-rich and nutrient-poor discrete layers can coexist under the ice cover to different extends depending on spring-melt chronology.

Publications

Taylor, B.R. and H.G. Jones, 1990. Litter decomposition under snow cover in a balsam for forest. Canadian Journal of Botany, 68(*), 112-120

Jones, H.G., 1988. Hydrogen ion flux through a snowcover during snowmelt in a boreal forest site. Verhandlungen, Internationale Vereinigung für Theoretische und Angewandte Limnologie, 23(*), 2286-2290

Jones, H.G. and Y. Bédard, 1987. The dynamics and mass balances of NO_3^- and SO_4^{2-} in meltwater and surface-runoff during spring melt in a boreal forest. In - Forest Hydrology and Watershed Management, IAHS Publication No.167, 19-31

Organization and Address National Hydrology Research Institute, 11, Innovation Blvd, Saskatoon, Saskatchewan, S7N 3H5	Tel.No. 306-975-5749
Department/Branch Hydrological Sciences Division	FAX No. 306-975-5143

Researchers

L. Lesack and P. Marsh

Project Title **Mackenzie Delta Lakes**	Status	New [ ] Ongoing [ ] Completed [X]

Objectives

Analysis of NHRI/FWI data sets. Collect sediment cores from a small number of lakes in the Mackenzie Delta and assess various methods to date the cores.

Methods

Lab [ ] Field [X] Modelling [X] Others

Findings

Results to date have provided the first analysis of long-term water levels in the Mackenzie Delta and their implications for the hydrology of lakes in the delta.

Very small wood samples in some lake sediment cores were dated but organic material could not be due to contamination by "old" carbon.

Publications

Bigras, S.C., 1989. Hydrological regime of lakes in the Mackenzie Delta, Northwest Territories, Canada. Arctic and Alpine Research, 22(2), 163-174

Marsh, P., 1990. Permafrost and lakes in the Mackenzie Delta. Proceedings, 5th Canadian Permafrost Conference, 6-8 June 1990, Québec, Quebec

Proceedings, Workshop on the Mackenzie Delta: 17-18 October 1989, Saskatoon
Ferguson, M., 1989. Sediment movement in lakes of the Mackenzie Delta.
Lesack, L.R.W., R.E. Hecky and P. Marsh, 1989. The influence of frequency and duration of flooding on the nutrient chemistry of Mackenzie Delta Lakes.
Marsh, P. and M. Hey, 1989. Spatial variations in the flooding of Mackenzie Delta Lakes.

Organization and Address National Hydrology Research Institute, 11, Innovation Blvd, Saskatoon, Saskatchevan, S7N 3H5	**Tel.No.** 306-975-5749
Department/Branch Hydrological Sciences Division	**FAX No.** 306-975-5143

Researchers

P. Marsh and T.D. Prowse

Project Title **Snowmelt Run-Off in High-Latitude Permafrost Basins**	**Status** **New** [ ] **Ongoing** [X] **Completed** [ ]

Objectives

Field inestigation at Resolute into snowmelt, water flux through the snow, melt metamorphism, infiltration into frozen soils, and snowmelt run-off.

Methods

Lab [ ] **Field** [X] **Modelling** [X] **Others**

Findings

Data on snowmelt, water flux through the snow, melt metamorphism, infiltration into frozen soils, and snowmelt run-off were obtained. New study sites were instrumented with ground thermistor strings, twin gamma tubes for measuring soil moisture, and frost heave tubes at sites on either side of the tree line near Inuvik.

Publications

Marsh, P., 1990. Snow hydrology. In - Northern Hydrology: Canadian Perspectives, T.D. Prowse and C.S.L. Ommanney (Editors), NHRI Science Report No.1, National Hydrology Research Institute, Saskatoon, Saskatchevan, 37-61

Marsh, P. and M.-K. Woo, 1989. Water fluxes in the Canadian High Arctic. International Symposium on Global Energy and Water Fluxes, IAHS, 31 July - 11 August 1989, Reading, U.K. [CS-89027]

Woo, M.-K. and P. Marsh, 1990. Response of soil moisture change to hydrological processes in a continuous permafrost environment. 8th International Northern Research Basins Symposium and Workshop, 26-30 March 1990, Abisko, Sweden, Water Resources Engineering, Luleå University of Technology, 28 pp. To be published in Nordic Hydrology [CS-89111]

Organization and Address Swift Current Research Station, Agriculture Canada, P.O. Box 1030, Swift Current, Saskatchevan, S9H 3X2	**Tel.No.** 306-
Department/Branch Swift Current Research Station	**FAX No.** 306-

Researchers

B.G. McConkey, R. Grover, R.W. Luciuk, H. Steppuhn and B.H. Sonntag

Project Title **Run-off and Water Quality from a Continuous Wheat System with Improved Snow Management**	**Status** **New** [ ] **Ongoing** [X] **Completed** [ ]

Objectives

Methods
Lab [ ] **Field** [ ] **Modelling** [ ] **Others**

Findings

Publications

Organization and Address National Hydrology Research Institute, 11, Innovation Blvd, Saskatoon, Saskatchewan, S7N 3H5	Tel.No. 306-975-5749
Department/Branch Hydrological Sciences Division	FAX No. 306-975-5143

Researchers
W. Nicholaichuk, K. Best, J. Pomeroy, R.J. Granger, D.M. Gray, B. McConkey and P.G. Landine

Project Title Snow Management and Snowmelt Infiltration Snow Accumulation	Status	New [ ] Ongoing [ ] Completed [X]

Objectives
Examine snowmelt enhancement by tillage practices; infiltration into cracked soils; effect on surface run-off and ground-water.

Methods
Lab [ ] Field [X] Modelling [X] Others

Findings
Up to 77% of annual snowfall may be removed by blowing snow; most evaporates before it collects in drifts. A 25-cm stubble reduces these losses by about 30%. Infiltration of snowmelt water is five times more into subsoiling rips than into unripped frozen soils. Subsoiling at 40-50 cm, 90-130 cm apart, permits complete infiltration of deep snowpacks.

Publications

Pomeroy, J., W. Nicholaichuk, D.M. Gray, B. McConkey, R.J. Granger and P.G. Landine, 1990. Snow management and meltwater enhancement: final report. NHRI Contribution No.90021, Physical Hydrology Division, National Hydrology Research Institute, Environment Canada, Saskatoon, Saskatchewan, 164 pp.

McConkey, B.G., H. Steppuhn, and W. Nicholaichuk, 1990. Effects of fall sub-soiling and snow management on water conservation and continous wheat yields in southwestern Saskatchewan. J. of Soil & Water Conservation

Nicholaichuk, W., K. Best, K. Fischer and M. Black, 1990. Groundwater by snow management and pumping spring runoff. Extended abstract, 43rd Annual CWRA Conference, 16-19 May 1990, Penticton, British Columbia, [CS-89063]

Organization and Address	Tel.No.
National Hydrology Research Institute, 11, Innovation Blvd, Saskatoon, Saskatchewan, S7N 3H5	306-975-5749
Department/Branch Hydrological Sciences Division	**FAX No.** 306-975-5143

Researchers

R. Perla, G. Kite and A. Wankiewicz

Project Title	Status	
Microwave Remote Sensing of Snow Water Equivalent	**New**	[ ]
	Ongoing	[X]
	Completed	[ ]

Objectives Organize a microwave remote sensing workshop. Develop theory and experiments on microwave radiometry of snow, soil and vegetation. Develop algorithms relating microwave data to stream flow.

Methods
Lab [X] **Field** [X] **Modelling** [X] **Others**

Findings

The Workshop on Application of Remote Sensing in Hydrology, organized by Geoff Kite, Anthony Wankiewicz and Ron Perla was held in Saskatoon, on February 13-14 and the proceedings were prepared, edited and printed.

Analysis was performed on the real portion of the dielectric constant of 200 snow samples at 0°C containing a wide range of liquid water, and a new model was developed based on interconnected microstructure. Some theoretical progress was made relating permeability to section measurements.

Publications

Kite, G.W. and A. Wankiewicz (Editors), 1990. Proceedings of the Workshop on Applications of Remote Sensing in Hydrology, 13-14 February 1990, Saskatoon, Saskatchewan. NHRI Symposium No.5, National Hydrology Research Institute, Environment Canada, Saskatoon, Saskatchewan, 386 pp.

Wankiewicz A., 1990. Radar and microwave radiometry: summary. Proceedings of the Workshop on Applications of Remote Sensing in Hydrology, G.W. Kite and A. Wankiewicz (Editors), 13-14 February 1990, Saskatoon, Saskatchewan, NHRI Symposium No.5, National Hydrology Research Institute, Environment Canada, Saskatoon, Saskatchewan, 361-362

Organization and Address	Tel.No.
National Hydrology Research Institute, 11, Innovation Blvd, Saskatoon, Saskatchewan, S7N 3H5	306-975-5749
Department/Branch Hydrological Sciences Division	**FAX No.** 306-975-5143

Researchers

T.D. Prowse and C.S.L. Ommanney

Project Title	Status	
Northern Hydrology Symposium	**New**	[ ]
	Ongoing	[X]
	Completed	[ ]

Objectives

Co-ordinate and edit a book on Canadian northern hydrology and write introductory chapter. Organize a conference on Northern Hydrology.

Methods

Lab [ ] **Field** [ ] **Modelling** [ ] **Others** Organizing and Editing

Findings

Chapters for the book were obtained, reviewed and edited and the book published. Abstracts for conference were revieved, accepted and prepared for abstract volume. A successful symposium was held in Saskatoon.

Publications

Prowse, T.D., 1990. Northern hydrology: an overviev. In - Northern Hydrology: Canadian Perspectives, T.D. Prowse and C.S.L. Ommanney (Editors), NHRI Science Report No.1, National Hydrology Research Institute, Environment Canada, Saskatoon, Saskatchevan, 1-36 [CS-90038]

Prowse, T.D. and C.S.L. Ommanney (Compilers), 1990. Programme and abstracts, Northern Hydrology Symposium, 10-12 July 1990, Ramada Rennaissance, Saskatoon, Saskatchevan. NHRI Contribution No.90041, National Hydrology Research Institute, Environment Canada, Saskatoon, Saskatchewan, 34 pp. [CS-90041]

Prowse, T.D. and C.S.L. Ommanney (Editors), 1990. Northern hydrology: Canadian perspectives. NHRI Science Report No.1, National Hydrology Research Institute, Environment Canada, Saskatoon, Saskatchevan, 324 pp.

Organization and Address	**Tel.No.**
Commercial Fisheries & Aquaculture Br., BC Ministry of Agriculture & Fisheries, Windsor Ct, Victoria, BC	
Department/Branch Aquaculture Operations	**FAX No.**

Researchers

Karl Ricker and John McDonald (Seakem Group, Sidney, B.C.)

Project Title	**Status**	
Biophysical Evaluation of the B.C. Coastline for Net Pen Salmonid Aquaculture Operations	**New**	[ ]
	Ongoing	[X]
	Completed	[ ]

Objectives

Evaluation of 16 parameters (incl.: hydrology, snowfall, avalanches, ice cover, etc.) to rate reaches of waterways as to suitability for aquaculture.

Methods

Lab [ ] **Field** [X] **Modelling** [ ] **Others**

Findings

Very few waterways are good aquaculture sites, many are useable with safeguards to be implemented and many are NOT ACCEPTABLE. Project began with (1) South mainland coast assessment (S or 50°N; then (2) West coast of Vancouver Island and low mid coast assessment (50-51°N); now (3) North coast and Queen Charlotte Islands (53-56°N). Deferred areas to be done later are: 94) Gulf Islands and S.E. coast of Vancouver Island, and (5) Mid coast area (51-53°N).

Publications

B.C. Ministry of Agriculture and Fisheries series

Organization and Address	Tel.No.
Avalanche Research Centre, National Research Council Canada, 3650 Westbrook Mall, Vancouver, B.C., V6S 2L2	604-666-6741
Department/Branch	**FAX No.** 604-666-7035

Researchers

Peter Schaerer and David McClung

Project Title	Status	
Prediction of Avalanche Hazards	**New**	[ ]
	Ongoing	[ ]
	Completed	[X]

Objectives

To develop guidelines for avalanche hazard forecasting by in-situ measurements of snow.

Methods

Lab [ ] **Field** [X] **Modelling** [ ] **Others**

Findings

Several techniques for in-situ measurements of snow stability were evaluated and recommendations made.

Publications

In preparation.

Organization and Address Dépt des Sciences Forestières, Univ. Laval, Cité universitaire, Ste-Foy (Québec), G1K 7P4	**Tel.No.**
Department/Branch Laboratoire d'hydrologie forestière	**FAX No.**

Researchers

Jean Stein

Project Title **Snowmelt Infiltration Processes in a Balsam Fir Forested Watershed**	**Status** **New** [ ] **Ongoing** [X] **Completed** [ ]

Objectives

Methods
Lab [ ] **Field** [ ] **Modelling** [ ] **Others**

Findings

Publications

Organization and Address Frank H. Theakston & Assoc. Inc., 335 Laird Road, Unit 1, Guelph, Ontario, N1H 6J3	Tel.No. 519-824-7656
Department/Branch	FAX No. 519-824-0774

Researchers

F.H. Theakston, M. Soligo, E. Brundrett and P. Kankainen

Project Title Automation of Snow and Wind Simulator for Snow and Wind Measurement	Status	New [ ] Ongoing [ ] Completed [X]

Objectives

To automate opem-channel water-flume measurement and computerize results of snow deposition and wind velocities.

Methods

Lab [ ] Field [ ] Modelling [X] Others

Findings

This project was sponsored by the National Research Council. It has proved to be invaluable in recording snow-depth measurements and wind-velocity measurements in a water flume and using model techniques. It is an innovation in the field of model analysis.

Publications

Soligo, M.J., F.H. Theakston, E. Brundrett and P. Kankainen, 1988. Automation of a water flume using microcomputer based data acquisition for snow and wind engineering. Proceedings of the 45th Annual Eastern Snow Conference, 8-9 June 1988, Lake Placid, New York, 162-175

Theakston, F.H. and M. MacKenzie, 1990. Modelling technique to reduce snow entrainment in building intake air. Proceedings, Annual eastern Snow Conference, Bangor, Maine,

Organization and Address	Tel.No.
National Hydrology Research Institute, 11, Innovation Blvd, Saskatoon, Saskatchewan, S7N 3H5	306-975-5749
Department/Branch Hydrological Sciences Division	**FAX No.** 306-975-5143

Researchers

A. Wankiewicz

Project Title	Status	
Multi-Satellite Monitoring of Hydrological Processes	**New**	[ ]
	Ongoing	[X]
	Completed	[ ]

Objectives

Analyze Nimbus 7 archived observations (March 15) to forecast yield from selected Canadian watersheds.

Methods

Lab [X] **Field** [ ] **Modelling** [X] **Others**

Findings

Analysis completed for February for five years of Nimbus 7 archived observations to forecast yield from 27 Canadian watersheds. Production of brightness temperature and streamflow data files and maps completed.

Publications

Organization and Address	Tel.No.
National Hydrology Research Institute, 11, Innovation Blvd, Saskatoon, Saskatchevan, S7N 3H5	306-975-5749
Department/Branch Hydrological Sciences Division	**FAX No.** 306-975-5143

Researchers

A. Wankiewicz

Project Title	Status	
Satellite Run-Off Forecasting	**New**	[ ]
	Ongoing	[X]
	Completed	[ ]

Objectives

Snowmelt run-off analysis of streamflow records and satellite-derived snowpack for the period 1979-1986. Derivation of storage run-off characteristics

Methods

Lab [X] **Field** [ ] **Modelling** [X] **Others**

Findings

In the microwave monitoring of Prairie streamflow, developments include: digital data analysis, streamflow separation, and API analysis for Plains basins.

Publications

Wankiewicz, A., 1990. Watershed moisture monitoring by microwave satellite. IGARSS '90 (in press)

Organization and Address	Tel.No.
National Hydrology Research Institute, 11, Innovation Blvd, Saskatoon, Saskatchewan, S7N 3H5	306-975-5749
Department/Branch Hydrological Sciences Division	FAX No. 306-975-5143

Researchers

A. Wankiewicz and R. Perla

Project Title	Status	
Microwave Remote Sensing of Basin Storage	New	[ ]
	Ongoing	[X]
	Completed	[ ]

Objectives

Study changes in microwave emissions from snow targets, simulate the snowpack development and derive algorithms for North American snow conditions

Methods

Lab [X] Field [ ] Modelling [X] Others

Findings

Developments included: Greenland calibration, new isoplething procedure, digital data reduction, cross-correlation analysis (microwave, snowfall, snowpack, streamflow), significance-of-errors analysis, Coast Mountains analysis, small-mountain-basin forecasting and mountain snowpack monitoring.

Publications

Wankiewicz, A., 1989. Microwave satellite forecasting of snowmelt runoff. In - Quantitative Remote Sensing: an Economic Tool for the Nineties, IGARSS '89, 12th Canadian Symposium on Remote Sensing, Vol.3, Wednesday July 12, Vancouver, British Columbia, IEEE #89CH2768-0, 1235-1238 [CS-89020]

Wankiewicz, A., 1989. Microwave satellite forecasting of snowmelt runoff. IEEE Transactions on Geoscience and Remote Sensing, [CS-89068]

Wankiewicz, A., 1990. Microwave satellite spring runoff correlations. Proceedings of the Workshop on Applications of Remote Sensing in Hydrology, G.W. Kite and A. Wankiewicz (Editors), 13-14 February 1990, Saskatoon, Saskatchewan, NHRI Symposium No.5, National Hydrology Research Institute, Environment Canada, Saskatoon, Saskatchewan, 331-344 [CS-90004]